Development of a High Energy Gamma-Ray Detector for Astrophysical Observations

Project Number: 96-18

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Purpose

To develop an instrument for efficient detection of 50 Gev-1Tev gamma rays from celestial sources. The instrument must reliably reject charged particles (cosmic rays) which are orders of magnitude more numerous than celestial source gamma rays. This rejection is necessary for practical telemetry rates and data analysis.

Background

The results of the "EGRET" detector on The Gamma-Ray Observatory have indicated that at least three classes of objects produce gamma rays above one billion electron volts (1 GeV). These are active galactic nuclei with particle jets (BLAZERS), pulsars, and gamma-ray bursts. Many EGRET discrete sources remained unidentified. Large area (few m^2) instruments with good energy and angular resolution above 1 GeV are required for further studies of these objects.

Approach

An "ionization calorimeter" instrument utilizing lead plates as an electron/photon cascade converter, and scintillating fibers as the sampling detectors, will be investigated. This kind of instrument may readily be expanded to large areas. Two kinds of charged particle rejection schemes will be investigated. One is a segmented version of the traditional scintillator "anticoincidence" detector. The other is near real-time recognition of the different shower types in the detector. Figure 52 is a schematic of the instrument showing layers of fibers sandwiched between lead plates. The fibers are viewed by photomultiplier tubes and intensified CCD cameras.

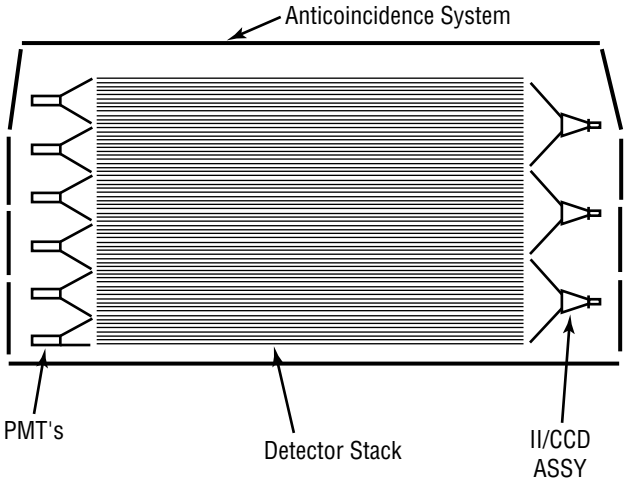

FIGURE 52.—Concept of the high energy gamma-ray instrument.

Accomplishments

- The simulations are 90 percent complete. Results show that a relatively coarsely sampled calorimeter (more lead than fibers) may be sufficient to separate photon and charged particle showers by recognizing the differences in shower development with a digital signal processor (DSP). Simulations

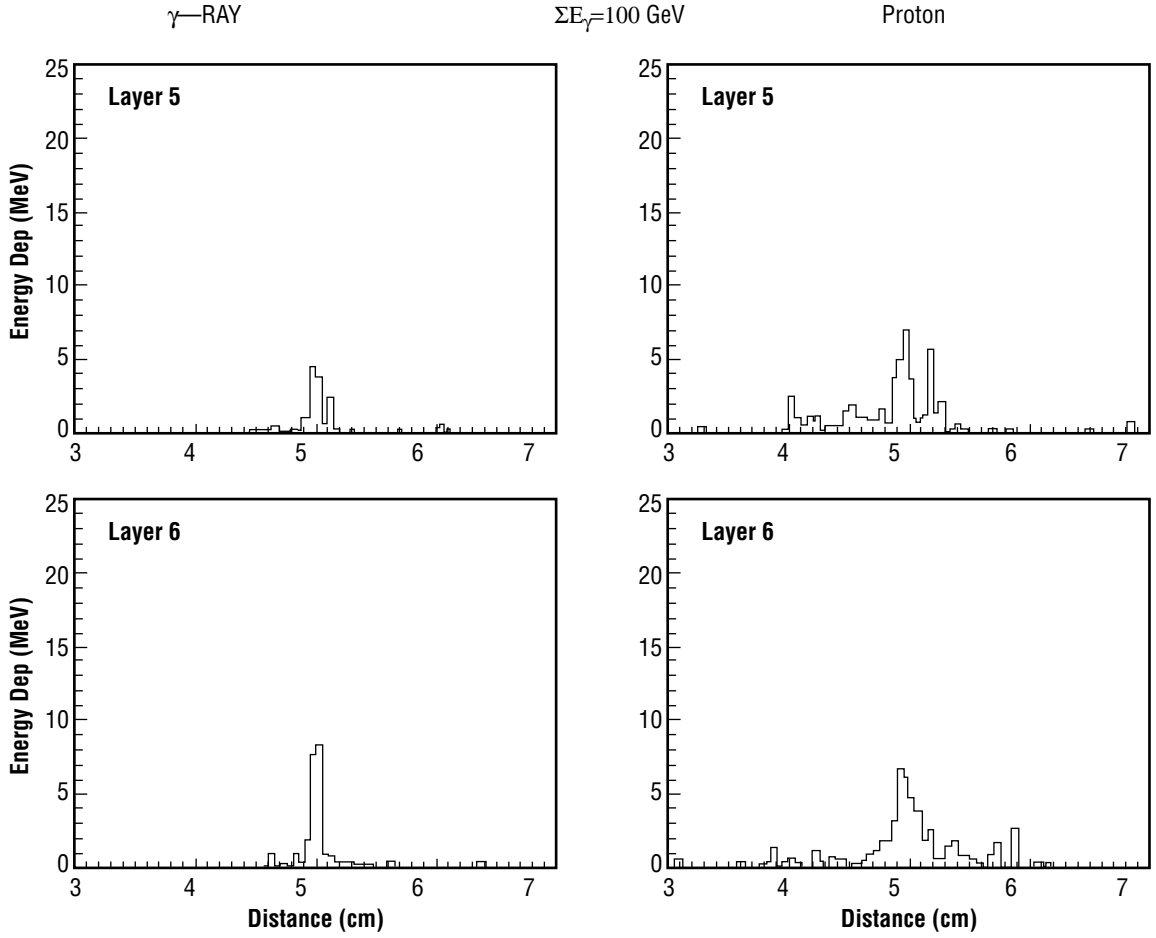

FIGURE 53.—Energy deposited by photon of 100 GeV and proton of ≈1000 GeV.

showed that an existing scintillating optical fiber calorimeter (SOFCAL) may be used for tests in the lab with cosmic ray showers. Figure 53 shows a sample of the simulated development of gamma rays and charged particle (proton) showers.

- A digital signal processor has been procured for near real-time separation of showers.

- The configuration of an "anti-coincidence" charged practice shield has been chosen. Scintillator samples have been procured and tests have been performed. The initial scintillating material had deficiencies in performance. New material is on order.

- A data system concept utilizing existing components from SOFCAL has been selected.
- An unexpected bonus from the simulations was of the predicted efficiency of a finely sampled fiber optics calorimeter for measuring electron-positron pairs from medium energy (10 MeV–30 GeV) gamma rays. This resulted in a successful astrophysics SRT proposal (SIFTER).

Planned Future Work

We plan to test components for the anti-coincidence detector, photomultiplier tubes, and an image intensifier/camera for a top fiber anti-coincident layer. We will then complete

simulations, including figure of merit for charged particle rejection, and assemble the laboratory instrument including all modifications to the SOFCAL instrument. We will then install and test the digital signal processor, and test the DSP using recorded data from the last balloon flight. The experiment will be performed in the laboratory using cosmic ray air showers. We will analyze the data to assess charged particle rejection ratio and energy and angular resolution for gamma rays. Finally, we will publish our report.

Funding Summary ($k)

	FY96	FY97	Total
Approved:	82	38.1	129.1
Obligated:*	55	64.8	119.8
Costed:			119.8
Remaining:	27	43	0.3

* Includes $50k for Sverdrup/Mevatek Technical Support

Status of Investigation

Project approved—October 1995

Estimated completion—FY98 with no additional funds